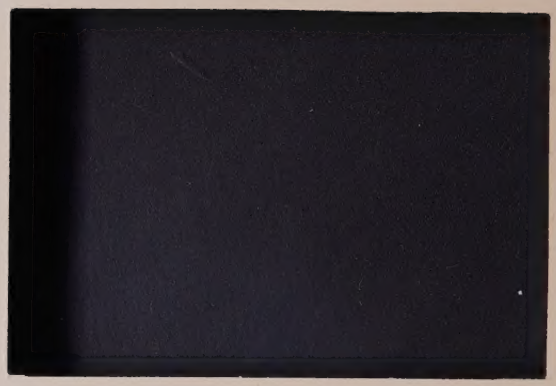
BALLANTINE LABORATORIES - BOONTON - N. J.

INSTRUCTIONS FOR THE

MODELS 300-E and F SENSITIVE ELECTRONIC VOLTMETERS

BALLANTINE ELECTRONIC INSTRUMENTS



INSTRUCTIONS FOR THE

MODELS 300-E and F SENSITIVE ELECTRONIC VOLTMETERS

INSTRUCTION BOOK CONTENTS
For
MODEL 300E and MODEL 300F
ELECTRONIC VOLTMETERS

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1. SPECIFICATIONS

SENSITIVE ELECTRONIC VOLTMETERS

MODEL 300E - COMMERCIAL VERSION
MODEL 300F - MILITARIZED VERSION

Voltage Range

300 microvolts to 300 volts in 6 ranges, in steps of 20 db

Frequency Range

30 cycles to 100,000 cycles

Accuracy

2% throughout frequency range and at any point on meter scale

Input Impedance

Range	R	C
0.003 volts	2,000,000 ohms	40 uuf
0.03 volts	2,000,000 ohms	30 uuf
0.3 volts	2,000,000 ohms	20 uuf
3.0 volts	2,000,000 ohms	20 uuf
30.0 volts	2,000,000 ohms	20 uuf
300.0 volts	2,000,000 ohms	20 uuf

Amplifier

Maximum gain is approximately equal to 45 db, response is ±1 db from 30 cycles to 100 KC, maximum output voltage is approximately 0.6 volt.

Null Detector

Meter is biased on scale when switch leg available at rear terminal board is closed.

Auxiliary Outputs

6.3 volts (line frequency) at 0.3 amps, and 250 volts DC at 1 ma. (available at rear terminal strip).

Input Connections

Binding posts on front panel, BNC connector in rear.

SPECIFICATIONS (Cont.)

Front Panel Isolation

The front panel is isolated from signal-ground for ultimate connection to systems ground.

Adjustments

Sensitivity and scale-decading available through access holes in instrument case.

Power Supply

105 volts to 125 volts, 60-400 cycles, 37 watts.

Tubes

4 Type 6AU6, 1 Type 0A2, 1 Type 6X4.

Dimensions

Panel Size. 5-1/4 x 9-1/2 inches.
Behind Panel. Depth - 9-1/2 inches,
Width - 8-1/4 inches.

Weight

Approximately 10 pounds.

2. GENERAL DESCRIPTION

The Ballantine Model 300E or F Voltmeter is an amplifier-detector type instrument designed primarily for the measurement of voltages in the audio spectrum. The Model 300E unit is a standard commercial voltmeter whereas the Model 300F unit is constructed with JAN components (except for the Weston indicating meter) and thus can be called a Militarized Version.

Essentially the voltmeter comprises a high impedance attenuator followed by a degeneratively stabilized amplifier which feeds an average responding rectifier-meter circuit.

Current from the rectifier circuit passes through a special logarithmically graded moving coil meter which has the logarithmic voltage and linear db scales associated with other well-known Ballantine voltmeters. The voltage is read with an accuracy unaffected by the position on scale of the value observed.

Input connections to the instrument are available at both front and rear. Binding posts are provided on the front panel while a BNC (UG-290-U) jack is provided in the rear. The two inputs are connected in parallel.

The instrument panel is isolated from the signal ground so that it may be ultimately connected to a systems ground. The maximum signal which may be introduced between the panel and signal ground is specified in Section 3.5.

The shaft of the range switch is extended at the rear of the instrument to permit adaptation to automatic programming.

By means of a switch leg, available at a pair of terminals on a rear terminal board, the zero-signal meter indication may be biased on scale, making the instrument more useful as a null detector.

Also available at a pair of rear terminals is an amplifier output, providing a gain of approximately 45 db. (See Section 4.1)

Voltages of 6.3 volts (±5%) at 0.3 amperes (line frequency), and 250 volts (±10%) dc at 1 milliampere are available at rear mounted terminals.

3. OPERATION

3.1 Power Connection and Warm Up

The Model 300E or F is supplied complete with tubes and fuse and is ready to operate as received. Connect the power cord to a source of power conforming with the specifications stated on the chassis adjacent to the power cord. See Schematic Diagram for line voltage conversion. Turn the ON-OFF switch located at the rear of the instrument to ON.

Allow a warm up period of 5 minutes before use, unless the instrument has not been in service for many months, in which case allow a warm up period of at least 30 minutes.

3.2 Voltage Measurement

Connect the voltage to be measured to the input terminals, observing the ground polarization. Rotate the range control until an on-scale indication is observed. The position of the range knob, together with the meter indication, gives the value of the voltage at the input terminals.

If a DC component is also present when making AC measurements, care must be taken to insure that this DC component does not exceed 600 volts (DC working voltage of input coupling capacitor). In the event that the DC component exceeds this value, an additional blocking capacitor, with the necessary DC working voltage may be placed in series with the input terminal. At low frequencies the value of this capacitance must be large enough (0.2 uf at 30 cycles) to prevent degradation of the low frequency accuracy of the voltmeter.

Although the instrument is designed to withstand rather severe overloads without damage, there are limits to the amount of overloading which may be safely imposed. In general, on the lower ranges, this is dictated by the maximum grid voltage which the amplifier input tube can withstand without damage. On the higher ranges the maximum voltage rating of components in the input attenuator restricts the maximum voltage which may be safely applied. Table I below lists the maximum overload ratios for the various ranges.

TABLE I

MAXIMUM OVERLOAD RATIOS

Range	Overload Ratio	Maximum Input
0.003 volt	30,000 to 1	100 volts
0.03 volt	3,000 to 1	100 volts
0.3 volt	3,000 to 1	1000 volts
3.0 volts	300 to 1	1000 volts
30.0 volts	30 to 1	1000 volts
300.0 volts	3 to 1	1000 volts

3.3 Current Measurement

By using the Ballantine Series 600 Shunt Resistors in conjunction with this voltmeter it is possible to measure AC currents from 0.3 microampere to 10 amperes. For a complete description of the accuracy, current, and frequency range of these shunt resistors, refer to the Ballantine catalog.

3.4 Input Impedance

At low frequencies the input terminals present a constant resistive component (2 megohms ±1%) to the input signal, while the capacitive component is a function of the range switch setting and is given in Table II. Although the capacitive component is essentially independent of frequency, the resistive component decreases as the higher frequencies are approached. Figure 1 shows the approximate variation of input resistance vs. frequency.

3.5 Panel Isolation

The Model 300E or F has been constructed so that the panel is electrically isolated from the chassis or instrument signal ground. This permits connection of the panel to a rack or system ground independent of the chassis. There is a limit, however, to the maximum voltage which may be introduced between panel and chassis without serious degradation of instrument accuracy. This maximum voltage is a function of signal source impedance, frequency, and voltmeter range. Listed in Table III are voltages which will introduce an additional 1% error when connected between panel and chassis, when the panel-chassis and signal voltages are of the same frequency.

If the Model 300E or F is used as a portable instrument, it is recommended that the panel be electrically connected to the chassis. Use of the Model 300E or F for above ground measurements is not recommended.

TABLE III

MAXIMUM PANEL-CHASSIS VOLTAGE FOR ADDITIONAL 1% ERROR WHEN PANEL-CHASSIS AND SIGNAL VOLTAGES ARE OF THE SAME FREQUENCY

Signal Source Impedance - 200,000 ohms			
Voltmeter Range	Frequency		
	30 Cycles	50 Cycles	1000 Cycles
0.003 volt	100 millivolts	50 millivolts	2 millivolts
0.03 volt	1 volt	500 millivolts	20 millivolts
0.3 volt	10 volts	5 volts	200 millivolts
3 volts			2 volts

Signal Source Impedance - 20,000 ohms			
Voltmeter Range	Frequency		
	30 Cycles	50 Cycles	1000 Cycles
0.003 volt	1 volt	0.5 volt	20 millivolts
0.03 volt	10 volts	5 volts	200 millivolts
0.3 volt			2 volts

TABLE II

INPUT CAPACITANCE VS. RANGE SWITCH SETTING	
Range	Capacitance
0.003 volt	40 uuf
0.03 volt	30 uuf
0.3 volt	20 uuf
3.0 volts	20 uuf
30.0 volts	20 uuf
300.0 volts	20 uuf

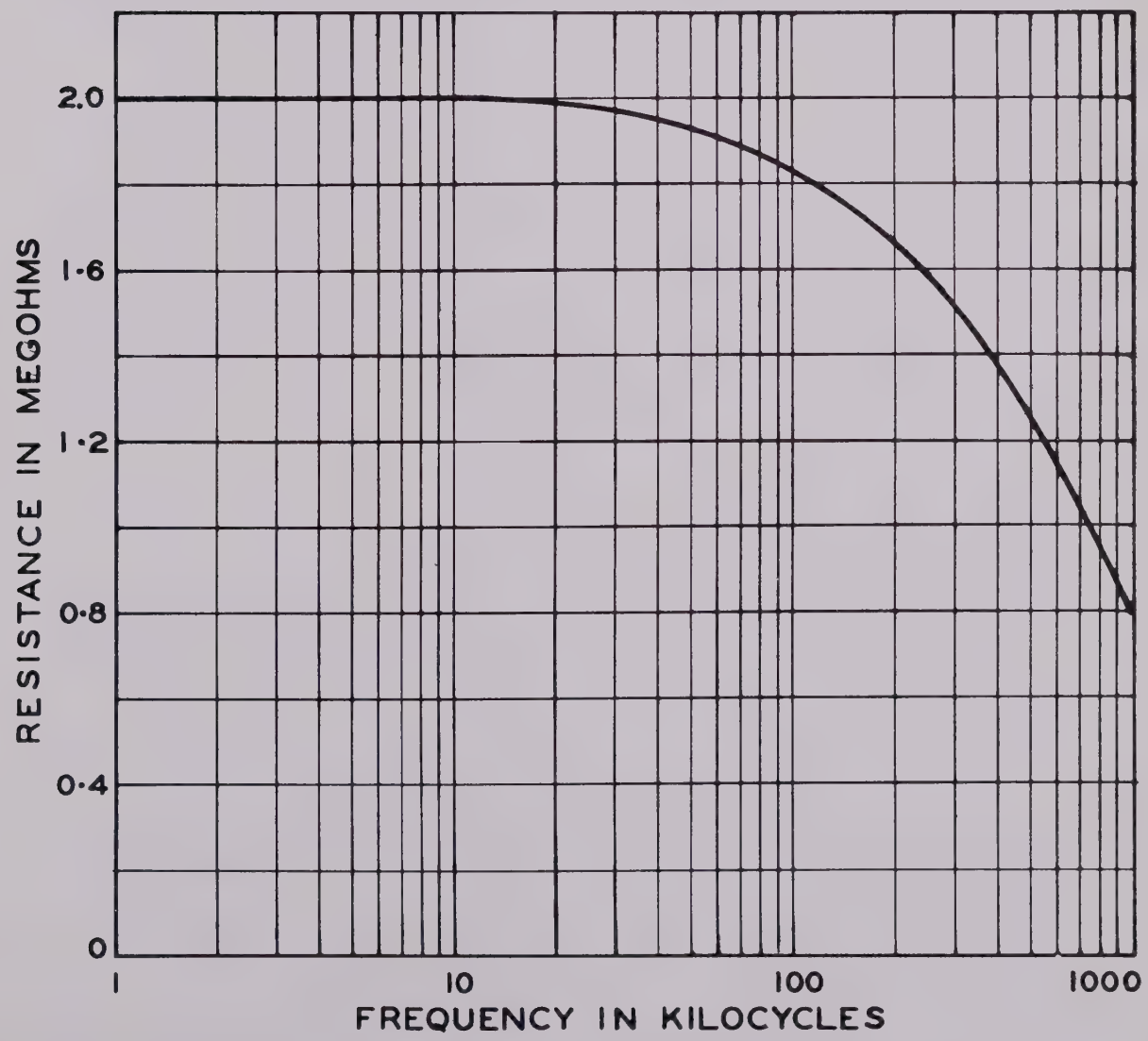


Fig. 1 INPUT RESISTANCE VS. FREQUENCY

4. AUXILIARY FUNCTIONS

4.1 Amplifier

A pair of rear mounted terminals, one of which is at signal ground potential, make it possible to use the instrument as an amplifier. The gain of the amplifier is approximately 45 db, reducible in steps of 20 db by means of the range switch on the front panel. The response of the amplifier is flat within plus or minus 1 db over the range of 30 cycles to 100 KC. The maximum output voltage is approximately 0.6 volt, while the output impedance is approximately 300 ohms in series with 0.1 mfd. The load impedance should always be sufficiently high so as not to impair performance as a voltmeter; 30,000 ohms or higher appears to cause no degradation of meter performance in the specified range. Although the output of the amplifier is neither linear nor distortion-free, the amplifier output has been included for those who may find it of some use in monitoring waveforms, etc.

4.2 Null Detector

Although the Model 300E or F possesses adequate sensitivity for most bridge measurement work, a condition may arise where the unbalanced voltage will be less than 300 microvolts, in which case the pointer of the voltmeter will fall below the left-hand extremity of the scale when working on the 0.003 volt range. By shorting a pair of rear mounted terminals marked NULL, a small bias current is supplied to the meter bringing the pointer to an on-scale reading even in the absence of an input signal. In this condition the instrument serves only to indicate the relative magnitudes of very low potentials.

4.3 250 Volts DC

A source of 250 (±10%) volts dc at a current of 1 milliampere is available at a pair of rear mounted terminals. The negative terminal is at signal ground potential. The ripple voltage, when operating from a 115 volt, 60 cycles source is approximately 0.2 volts and is predominantly 120 cycles.

4.4 6.3 Volts

A source of 6.3 (±5%) volts at 0.3 amperes and line frequency is available at a pair of rear mounted terminals. This potential is balanced with respect to signal ground.

5. CIRCUIT DESCRIPTION

A block diagram, schematic and replacement parts list are included at the end of this instruction book.

5.1 Input Attenuator

Since the amplifier of the Model 300E or F always operates with the same basic sensitivity (0.0003 volt to 0.003 volt), an attenuator must be provided at the input for reducing higher voltages to this range.

Actually the input attenuator of this Model 300E or F consists of three separate attenuators. See schematic diagram at rear of instruction book. Table IV is a listing of range switch settings and attenuation ratios.

TABLE IV

ATTENUATOR RATIOS

Range	Attenuation Ratio
0.003 volt	1
0.03 volt	10
0.3 volt	100
3.0 volt	1,000
30.0 volt	10,000
300.0 volt	100,000

Except for one range (0.03 volt) the attenuation ratio is determined at all frequencies in the specified range by the attenuator resistors alone. On the 0.03 volt range capacitive compensation is used at the higher frequencies. On this range the crossover from a resistive to a capacitive attenuator occurs at about 25,000 cycles. Capacitor C2 (see schematic diagram at rear of instruction book) provides a means of adjusting the high frequency response on this range. Note. The user is cautioned against making any adjustment of C2 without first reading Section 6.3.4.

5.2 Amplifier

The amplifier consists of four capacitively coupled pentode stages, the first three of which are operated to provide voltage gain while the final stage is used as a transducer to convert voltage to current for the rectifier-meter circuit. For an amplifier output, the signal voltage developed across the unbypassed cathode resistor of the final stage is employed.

Local feedback as well as overall feedback (32 db or greater) is employed to minimize distortion and gain changes from whatever cause. The amplifier response without feedback is shaped to fall off from the midband value at a rate of approximately 6 db per octave. As a result of this, and the amount of feedback available, the stability of the amplifier at the band extremes (30 cycles and 100 KC) is essentially that of midband.

The high and low frequency response of the amplifier is inherently flat; hence there are no adjustments relating thereto.

The gain or sensitivity of the amplifier is adjustable over a small range by means of R16 in the feedback network. See Section 6.3.3.

The heater of the input amplifier stage is operated on DC to minimize the line frequency signal components injected in this low level stage. Thus the error introduced when measuring voltages of line frequency and its harmonics is substantially reduced.

5.3 Rectifier-Meter Circuit

AC current available from the last amplifier stage is passed through the rectifier meter circuit and the feedback network to ground.

The rectifier is of the full wave bridge type employing semi-conductor diodes. Direct current from it passes through meter M1. The capacitor across M1 serves to reduce the indicator flutter at the lower frequencies. The response of the circuit is average, although the meter is calibrated RMS in terms of a sine wave.

Resistors R38 and R40 provide for an adjustment of the meter indication at 3 on scale. See Section 6.3.2. A small current, determined primarily by the value of R40 and the potential with respect to ground at the top of the rectifier-meter circuit, is passed down through the rectifier circuit. The division and direction of this current through the meter is determined by the position of the slider on R38.

The signal rectifiers are hermetically sealed, small area silicon junction diodes which are virtuallyimmune to aging and environmental conditions. The inherently non-linear characteristic of the diode rectifier is reduced to negligible proportions by incorporating the rectifier circuit within the feedback loop.

5.4 Power Supply

Amplifier plate and screen voltages are obtained from a full wave vacuum tube rectifier employing an RC filter, and a gaseous regulator tube. Low voltage DC power for the first amplifier stage heater is obtained from a full wave rectifier employing hermetically sealed silicon junction diodes, and a capacitive filter. All other amplifier heaters are operated on AC, balanced with respect to ground.

6. MAINTENANCE AND SERVICING

Limited servicing of the instrument by the user is feasible, providing the procedures outlined in this section are followed. However, it cannot be emphasized too strongly that the work should be entrusted only to technicians having the highest skill and experience in measurement techniques. A refined and comprehensive method of recalibration is beyond the scope of this manual and cannot be effected without specialized equipment having an order of accuracy much greater than that of the instrument being checked. Such equipment and personnel trained in its use are available in the Calibration Department of Ballantine Laboratories, Inc., so that if trouble developes which cannot be corrected except by the replacement of special components, it is recommended that the instrument be returned to Ballantine Laboratories, Inc. for servicing. The instrument in all cases should be preceded by a letter indicating the fault or desired service.

6.1 General Instructions

6.1.1 Fuse Replacement - The fuse is of the Slo-Blow type and is rated at 0.4 ampere for 115 volts operation and 0.2 ampere for 230 volts operation. The fuse holder is of the extractor post type located at the rear of the chassis.

6.1.2 Line Voltage Conversion - It is possible to operate the instrument from either a 115 volt or 230 volt line supply. To convert from 115 to 230 volt operation, or vice versa, see the schematic diagram located at the back of this manual.

6.2 Periodic Checks

6.2.1 Equipment Required -

a. A stable, distortion free, and accurately calibrated source of voltage with a signal frequency in the range of 400 - 1000 cycles. Output of the source should be continuously variable over a range of at least 1.0 millivolt to 10.0 volts. The Ballantine Model 420 Precision Calibrator (see specification sheet at the back of this manual) is such a source of voltage.

b. A stable, distortion free, variable frequency signal generator covering a range of at least 30 cycles to 100 KC. The output should be variable over a range of at least 1.0 millivolt to 3.0 volts.

c. A stable, sensitive, flat responding voltmeter covering a frequency range of at least 30 cycles to 100 KC, and a voltage range of 1.0 millivolt to 1000.0 volts. The Ballantine Model 300D (see specifi cation sheet at the back of this manual) is such a voltmeter.

6.2.2 2000 Hours Operation Check - At the end of each 2000 hours of operation it is recommended that the checks outlined in the following Sections be made.

6.3.1 Attenuator Decading
6.3.2 Scale Adjustment
6.3.3 Accuracy Adjustment
6.3.4 High Frequency Response
6.3.5 Low Frequency Response

6.2.3 4000 Hours Operation Check - At the end of each 4000 hours of operation it is recommended that all vacuum tubes be replaced and the checks outlined in the following sections be made.

6.3.1 Attenuator Decading
6.3.2 Scale Adjustment
6.3.3 Accuracy Adjustment
6.3.4 High Frequency Response
6.3.5 Low Frequency Response

6.3 Performance Checks

6.3.1 Attenuator Decading - When the signal input to the instrument is increased or decreased by precise factors of 10, and the range switch changed accordingly, the indication of the instrument should not vary by more than ±0.1%. Thus, if the instrument is indicating 5.0 on a given range, increasing the input by a factor of 10 (±0%) and switching to the next higher range, should produce an indication of 5 (±0.1%). Decading checks should be made with an undistorted sine wave signal of midband frequency (400 to 1000 cycles).

There are no controls or adjustments relating to the attenuator decading, this factor being solely determined by the attenuator resistors. If it is discovered that the decading is in error, in all probability one or more of the attenuator resistors has changed in value. However, some of the other possible sources of difficulty are -

a. Grid current in the amplifier input tube, V1.

b. Misadjustment of Capacitor C2. Note. No adjustment of C2 should be made without reference to Section 6.3.4.

The resistors employed in the attenuator are hermetically sealed film type of advanced design, exhibiting a stability approaching that of wire wound units, but free from the reactive effects inherent in the latter. Initially the resistors are matched to a tolerance of ±0.1%, in addition to which the temperature coefficients of the various values are closely matched. In view of the above it is recommended that the user make no resistor replacements, except perhaps as an emergency measure on a temporary basis. It is recommended that the instrument be returned to Ballantine Laboratories, Inc. for servicing.

6.3.2 Scale Adjustment - When an undistorted sine wave signal produces a deflection of precisely 30 on a given range, switching to the next higher range should produce a deflection of precisely 3.0 on scale. During its calibration at Ballantine Laboratories, Inc., the instrument is very carefully adjusted for this condition, and it should seldom, if ever, be found necessary to readjust. In the event that readjustment does become necessary, the control relating thereto is R38, and is available through an access hole in the left-hand side of the instrument case. See Fig. 2.

To make the scale adjustment connect an undistorted sine wave of midband frequency (400 - 1000 cycles) to the input terminals and adjust the amplitude for an indication of precisely 30 on any range (except the 300 volt range). Switch the instrument range knob to the next higher range. The indication should be precisely 3.0. Because of the relatively high damping at the low end of the meter scale, sufficient time should be allowed to permit the indicating needle to come to its final position. It is also recommended that the meter be tapped lightly to remove any effects of pivot friction. If the indication is not precisely 3.0, correct by means of control R38. Recheck and readjust if necessary.

6.3.3 Accuracy Adjustment - The design of the instrument is such that it should maintain its accuracy over extended periods of time and use. At Ballantine Laboratories, Inc. this accuracy is very carefully adjusted and checked. Moreover, an attempt is made to distribute the various inherent errors, so that the best possible overall accuracy results. The user, therefore, is cautioned against making any readjustments without fully determining that the instrument is in error.

All checks of accuracy should be made with an undistorted sine wave at a midband frequency (400 - 1000 cycles). The external standard meter, if used, should be accurate to 0.25% or better, and preferably of the RMS responding type.

If it has been established that the instrument is in error, the first attempt at correction should be tube replacement. Access to the tubes may be had by removing the top cover plate of the instrument.

If tube replacement does not restore accuracy, a small adjustment is possible with control R16, available through an access hole in the left hand side of the case. See Fig. 2. A larger adjustment is available by changing the value of R17, although the necessity to change this value is good indication that something else is at fault in the instrument.

To adjust the accuracy, first check the scale adjustment as outlined in Section 6.3.2 and readjust if necessary. Next connect an undistorted sine wave signal of midband frequency (400 - 1000 cycles) to the input terminals and check the accuracy at at least 10 points throughout the scale, noting the error and its sign at each point. Readjust R16 so that the maximum positive and maximum negative errors are equal in magnitude.

6.3.4 High Frequency Response - A discussion of all the factors entering into high frequency response of this instrument is beyond the scope of this manual. The basic voltmeter has no adjustments relating thereto, the instrument being inherently flat up to its specified top frequency. One attenuator range (0.03 volt) has an adjustment (C2) and a procedure for making this adjustment will be outlined below. All checks of response must be made with a distortion free sine wave signal, and the instrument used as a reference must have an extremely low response error over the range of 400 cycles to 100 KC.

On the most sensitive range of the instrument the response is determined solely by the amplifier and meter rectifier circuit. On all other ranges the attenuator response enters in also.

To check the high frequency response of the instrument connect together the instruments shown in Fig. 3. Set the signal generator to a frequency of 1000 cycles, the output of the signal generator to a level consistent with the range of the Model 300E or F which it is desired to check, and the level monitor for a suitable indication. Note the indications on both the Model E or F and the level monitor. Next set the signal generator to frequencies of 10 KC, 50 KC, 70 KC and 100 KC, in each case keeping the indication on the level monitor the same as it was at 1000 cycles, and noting the indication of the instrument under test.

If it has been determined that the instrument response is in error at the high frequencies, the response of the most sensitive or amplifier range should be checked. If the response of this range is found normal, the trouble must be in one or more of the attenuators.

If the response of the most sensitive range is not normal, the first attempt at correction should be tube replacement. If tube replacement does not restore normal response, one or more of the following items may be defective -

a. Capacitors - C5, C9

b. Resistors - R10, R12, R21, R28, R34

c. Signal diodes - CR1, CR2. These units are of a hermetically sealed silicon junction type, which are virtually immune to shock, vibration, temperature, aging effects, etc. and it is not very likely that they will ever be the source of trouble.

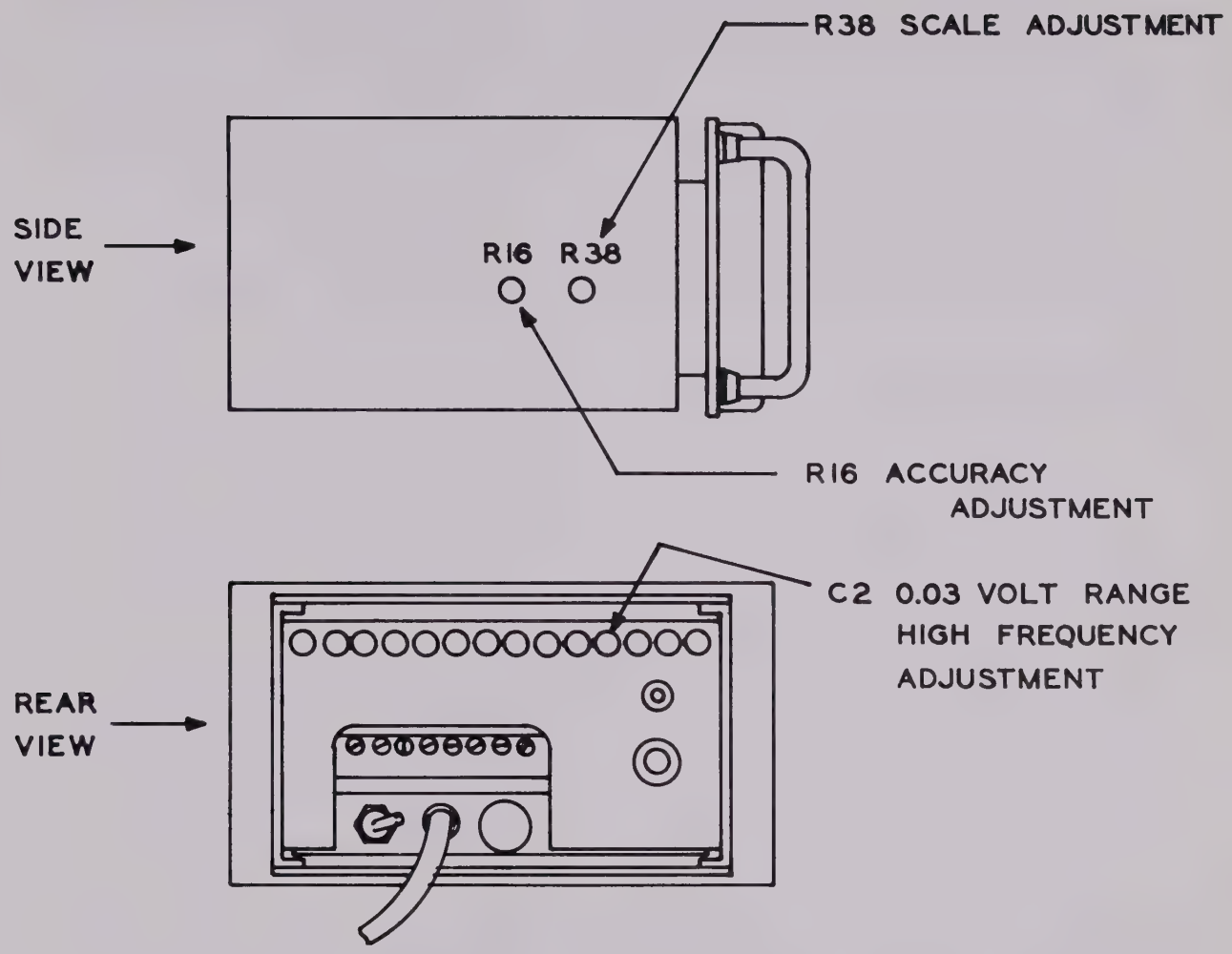


FIG. 2 INSTRUMENT ADJUSTMENTS

NOTE: READ SECTIONS 6.3.2, 6.3.3 AND 6.3.4 BEFORE READJUSTING ANY OF THE ABOVE

If the response is normal on the most sensitive range, but error exists on the 0.03 volt range, capacitor C2 should be adjusted for flattest response or best agreement with the most sensitive range. Access may be had to C2 through a hole in the rear chassis cover. See Fig. 2. If adjustment of C2 fails to establish normal response, Capacitor C3 may be defective. Access to C3 may be had by removing the top chassis cover and then the attenuator shield.

The four remaining attenuator ranges (0.3, 3.0, 30 and 300 volts) have an inherently flat response over the range of the instrument. There are, therefore, no adjustments relating to these ranges.

If the above procedure fails to establish normal high frequency response it is recommended that the instrument be returned to Ballantine Laboratories, Inc. for servicing.

6.3.5 Low Frequency Response - The low frequency response is determined solely by the amplifier, rectifier-meter portion of the instrument and hence is independent of range switch setting. This response is inherently flat and there are no controls or adjustments relating thereto.

To check the low frequency response connect together the instruments shown in Fig. 3. Set the signal generator to a frequency of 1000 cycles and set the range switches on the instrument being checked and the level monitor to give on-scale deflections, noting the indication of each. Next set the signal generator to frequencies of 100, 70, 50 and 30 cycles, in each case keeping the indication on the level monitor the same as it was at 1000 cycles, and noting the indication of the instrument under test. This indication should be constant within ±1%.

If this response is abnormal, the first attempt at correction should be tube replacement. In particular V1, V2, V3 and V4 should be checked for grid current. Abnormal grid current may be detected by voltages on grid number 1 which exceed those specified in Table V under Section 6.4.2. Other components, which if defective, might lead to abnormal low frequency response are -

a. Coupling capacitors C1, C7, C10, C11, C13, C14, C17 and C18.

b. Bypass Capacitor C6.

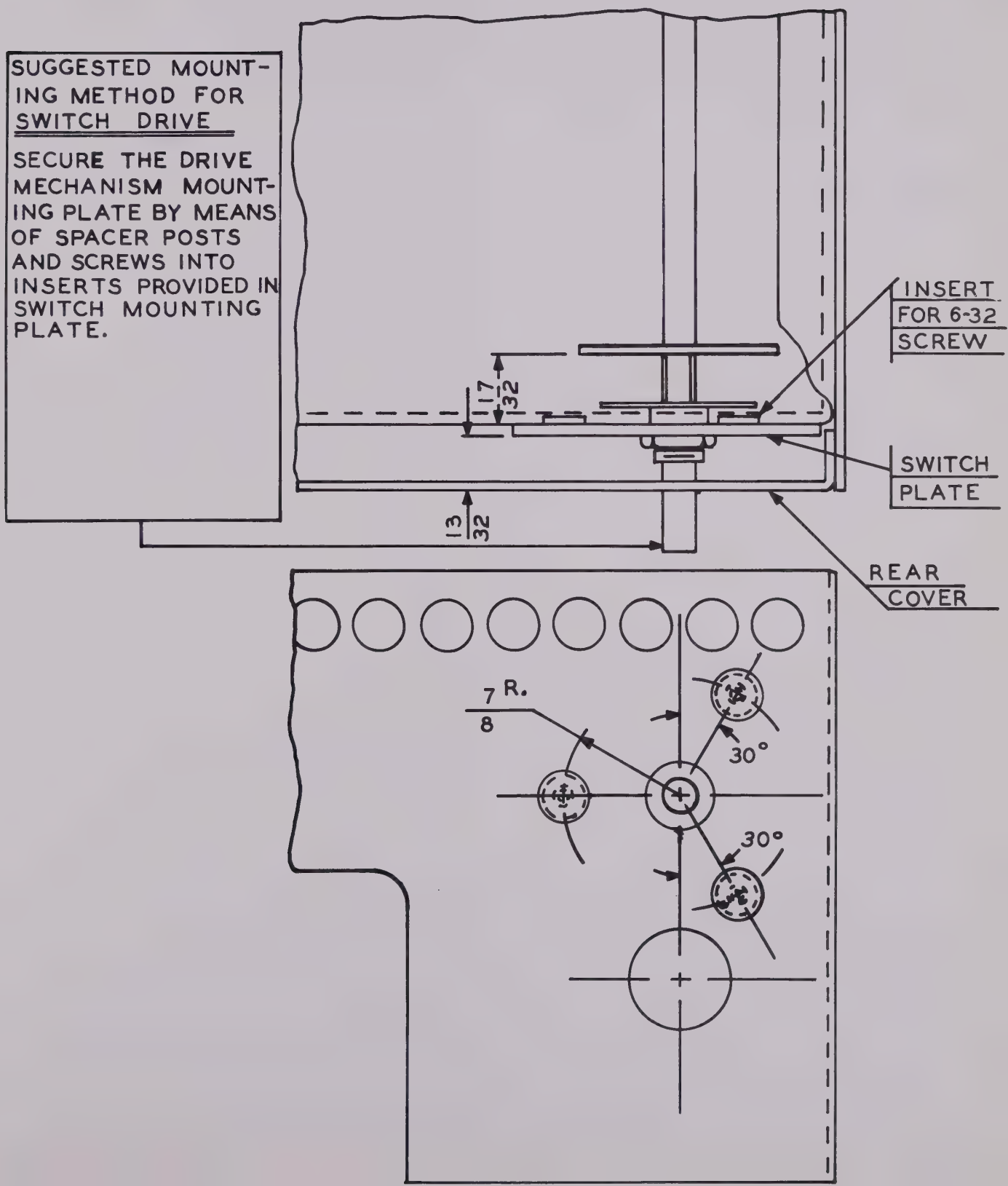
c. Decoupling Capacitors C8 A, B, C, C12 A, B, C, C15A.

d. Regulator tube V5.

MOUNTING DETAIL
FOR
RANGE SWITCH DRIVE

SUGGESTED MOUNTING METHOD FOR SWITCH DRIVE

SECURE THE DRIVE MECHANISM MOUNTING PLATE BY MEANS OF SPACER POSTS AND SCREWS INTO INSERTS PROVIDED IN SWITCH MOUNTING PLATE.



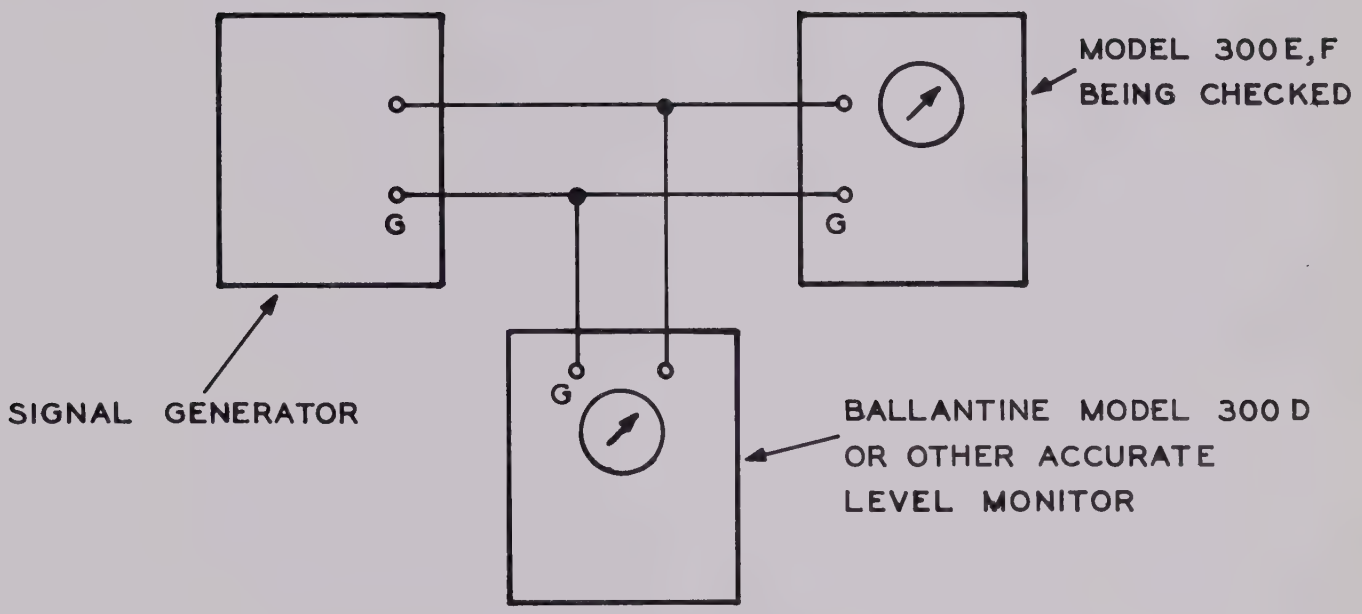


FIG. 3

FREQUENCY RESPONSE CHECK

6.4 Trouble Shooting

6.4.1 Equipment Required -

a. A stable, distortion free, and accurately calibrated source of voltage with a signal frequency in the range of 400 to 1000 cycles. The output of the source should be continuously variable over a range of at least 1 millivolt to 10 volts. The Ballantine Model 420 (see specification sheet at the back of this manual) is such a source.

b. A stable, distortion free, variable frequency signal generator covering a range of at least 30 cycles to 100 kilocycles, the output of which should be variable over a range of at least 1 millivolt to 3 volts.

c. A stable, sensitive, flat responding voltmeter covering a frequency range of at least 30 cycles to 100 kilocycles, and a voltage range of 1 millivolt to 1000 volts. The Ballantine Model 300D (see specification sheet at the back of this manual) is such a voltmeter.

d. A volt-ohm-milliameter exhibiting an input impedance of at least 10 megohms or higher when measuring DC voltages.

6.4.2 General Malfunction - In case of malfunction, as evidenced by insufficient or even absence of response, instability, high hum or noise level, intermittent operation or other disturbance, the first step is to check all tubes, replacing any which exhibit low gm, grid current, shorts, etc.

- N O T E -

VOLTAGES DANGEROUS TO HUMAN LIFE EXIST IN THIS EQUIPMENT. EXERCISE EXTREME CARE WHENEVER THE COVER PLATES ARE REMOVED FROM THE INSTRUMENT.

With all tubes operating normally the voltage at the tube elements may be measured and checked against Table V. All measurements should be made with the instrument input terminals short circuited and the range switch on the most sensitive range.

NOTE - IT IS POSSIBLE TO DAMAGE THE SIGNAL DIODES, IF THE PLATE OF V4 IS ACCIDENTALLY CONNECTED TO THE CHASSIS OR GROUND. IT IS ALSO POSSIBLE TO DAMAGE THE DIODES, METER, OR BOTH IF VIRTUALLY ANY PORTION OF THE METER RECTIFIER CIRCUIT IS GROUNDED. THE USER IS THEREFORE CAUTIONED TO TAKE EXTREME CARE WHEN MEASURING IN THIS SECTION OF THE INSTRUMENT.

The instrument used to measure DC potentials should have an input resistance of not less than 10 megohms. Any radical departure (in excess of 15%) from the voltages indicated in Table V may indicate the nature of the trouble.

In the event of a defective component it should be replaced in accordance with the Replacement Parts List located at the end of this manual. If the component or components are not available locally, they may be obtained from Ballantine Laboratories, Inc.

TABLE V

TUBE ELEMENT POTENTIALS

Tube	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7
V1 6AU6	0 to ±0.2v	1.43v	3.05v	3.05v	60v	62v	1.43v
V2 6AU6	0 to ±0.2v	1.48v	*3.15v	*3.15v	62v	85v	1.48v
V3 6AU6	0 to ±0.2v	1.45v	*3.15v	*3.15v	92v	90v	1.45v
V4 6AU6	0 to ±0.2v	1.55v	*3.15v	*3.15v	74v	120v	1.55v
V5 OA2	150v	0	-	0	150v	-	0
V6 6X4	*350v	-	*6.3v to Pin 4	*6.3v to Pin 3	-	*350v	390v

All measurements made with respect to chassis ground unless otherwise indicated. All voltages DC unless otherwise indicated. *AC voltages.

6.4.3 Signal Tracing - In the event that the procedure thus far fails to reveal the nature of the trouble, recourse may be made to signal tracing. The procedure is as follows -

a. With the instrument on the 0.3 volt range, connect a signal of 3 millivolts, 1000 cycles, to the input terminals.

b. Short out the feedback resistor R18.

c. Measure the signal voltages at the grids of V2, V3, V4 and the plate of V4 using a sensitive, high input impedance voltmeter such as the Ballantine Model 300D. When making these measurements precautions should be taken against introducing spurious signals into high impedance circuits. Operating the instrument on a grounded plate with the operator making contact with this ground should be sufficient.

-NOTE-

BECAUSE OF THE PRESENCE OF HIGH VOLTAGES, DO NOT MAKE CONTACT WITH GROUND UNTIL THE DESIRED CONNECTION HAS BEEN MADE AND THE HAND REMOVED THEREFROM. OBSERVE SAME PRECAUTION WHEN REMOVING CONNECTIONS.

Compare the voltages measured with those listed on the schematic diagram located at the rear of this manual. Any radical departure (greater than ±10%) from the voltages indicated may indicate the nature of the trouble.

6.4.4 Power Supply Malfunction - The power supply of this instrument is of extremely simple design and, except for vacuum tube (V5, V6) replacement, should seldom if ever cause any trouble. The diodes (CR3, CR4) employed in the DC heater supply are of the hermetically sealed silicon junction type and have a virtually limitless life.

On the schematic diagram located at the rear of this manual are the pertinent DC, AC and ripple (for both 60 cycles and 400 cycles operation) voltages. Measurements of these voltages should be made with zero signal input, and the instrument range knob set to 300 volts. Any radical departure from these voltages may indicate the nature of the trouble.

6.4.5 Trouble Shooting Chart - To assist in trouble shooting, a chart has been prepared which lists symptoms, possible cause and/or remedy, and where possible, a reference to a pertinent section of the manual.

TROUBLE SHOOTING CHART

SYMPTOM	POSSIBLE CAUSE AND/OR REMEDY	PERTINENT SECTIONS
Instrument inoperative	Fuse blown.	6.1.1
	ON-OFF switch.	
	Line cord.	
	Power supply defective.	5.4, 6.4.4
	Vacuum tubes V1, V2, V3, V4.	
	Amplifier component.	5.2, 6.4.3
	Signal diode CR1, CR2.	5.3
	Meter.	5.3
	Capacitor C16.	5.3
Erratic meter indication	Vacuum Tubes V1, V2, V3, V4, V5, V6.	
	Attenuator switch or component.	5.1, 6.4.5
	Amplifier component.	5.2, 6.4.3
	Power supply component.	5.4, 6.4.4
Meter indicating with zero input signal	Excessive heater-cathode leakage V1, V2, V3, V4.	
	Capacitor C18.	
	Resistor R38 or R40.	5.3
	Amplifier oscillating.	5.2, 6.4.3
Microphonics	V1 excessively microphonic.	
	Imperfectly soldered connection.	
	Poor electrical contact in range switch.	
Excessive hum (meter beats when signals near line frequency or harmonics are measured)	Excessive heater-cathode leakage V1, V2.	
	Instrument being operated in strong magnetic field of another instrument or equipment. Ground current flowing in signal carrying lead.	
Scale adjustment off - impossible to correct by means of R38	Vacuum tube V1, V2, V3, V4.	
	Diode CR1, CR2.	
	Resistor R38, R40.	5.3, 6.3.2
	Capacitor C16, C17, C18.	

TROUBLE SHOOTING CHART

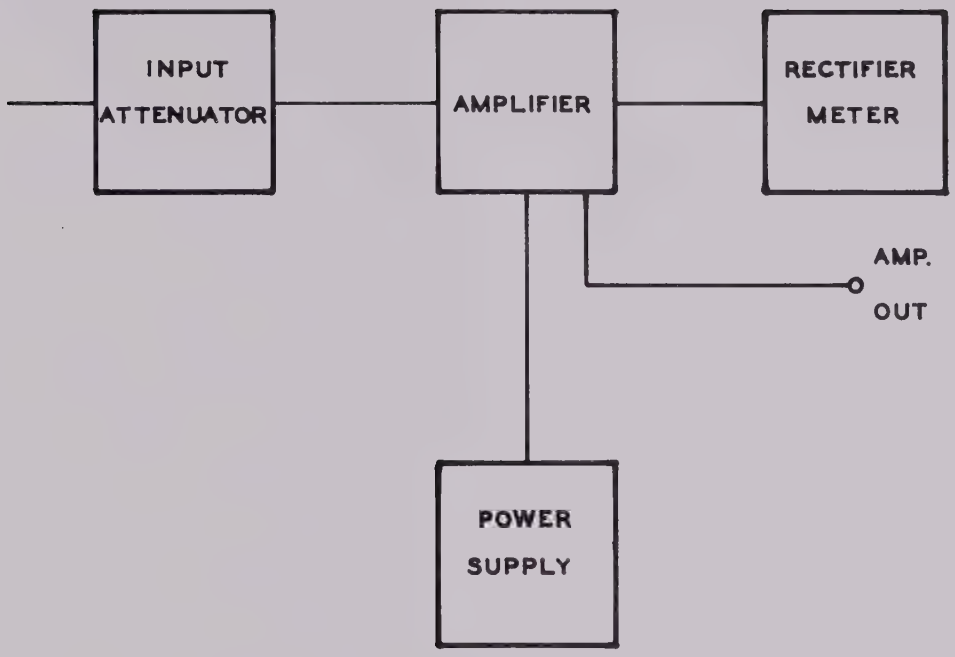
SYMPTOM	POSSIBLE CAUSE AND/OR REMEDY	PERTINENT SECTIONS
Range switch does not decade	Resistor R1, R2, R3, R4, R5, R6, R7, R8.	5.1, 6.3.1
	Capacitor C2, C3.	5.1, 6.3.1
	Amplifier tube V1 (excessive grid current).	
Accuracy off - adjustment of R16 does not correct	Attenuator resistor R1, R2, R3, R4, R5, R6, R7, R8.	5.1, 6.3.1
	Scale adjustment not properly made.	5.3, 6.3.2
	Amplifier tube V1, V2, V3, V4.	
	Defective diode CR1, CR2.	
	Meter M1.	
Abnormal high frequency response	Amplifier tube V1, V2, V3, V4.	
	Diode CR1, CR2.	
	Capacitor C5, C9, C2, C3.	5.2
Abnormal low frequency response	Amplifier tube V1, V2, V3, V4.	
	Capacitors C1, C7, C10, C11, C13, C14, C17, C18, C8A,B,C, C15A.	5.2
	Regulator tube V5.	
	Diode CR1, CR2.	

7. WARRANTY

Each Ballantine Laboratories, Inc. instrument or part thereof is warranted to be free from defects in material and workmanship. Ballantine Laboratories, Inc. obligation under this warranty is limited to repairing or replacing any instrument or part thereof, except vacuum tubes, which shall within one year after shipment to the original purchaser prove upon Ballantine Laboratories, Inc. examination to have become defective.

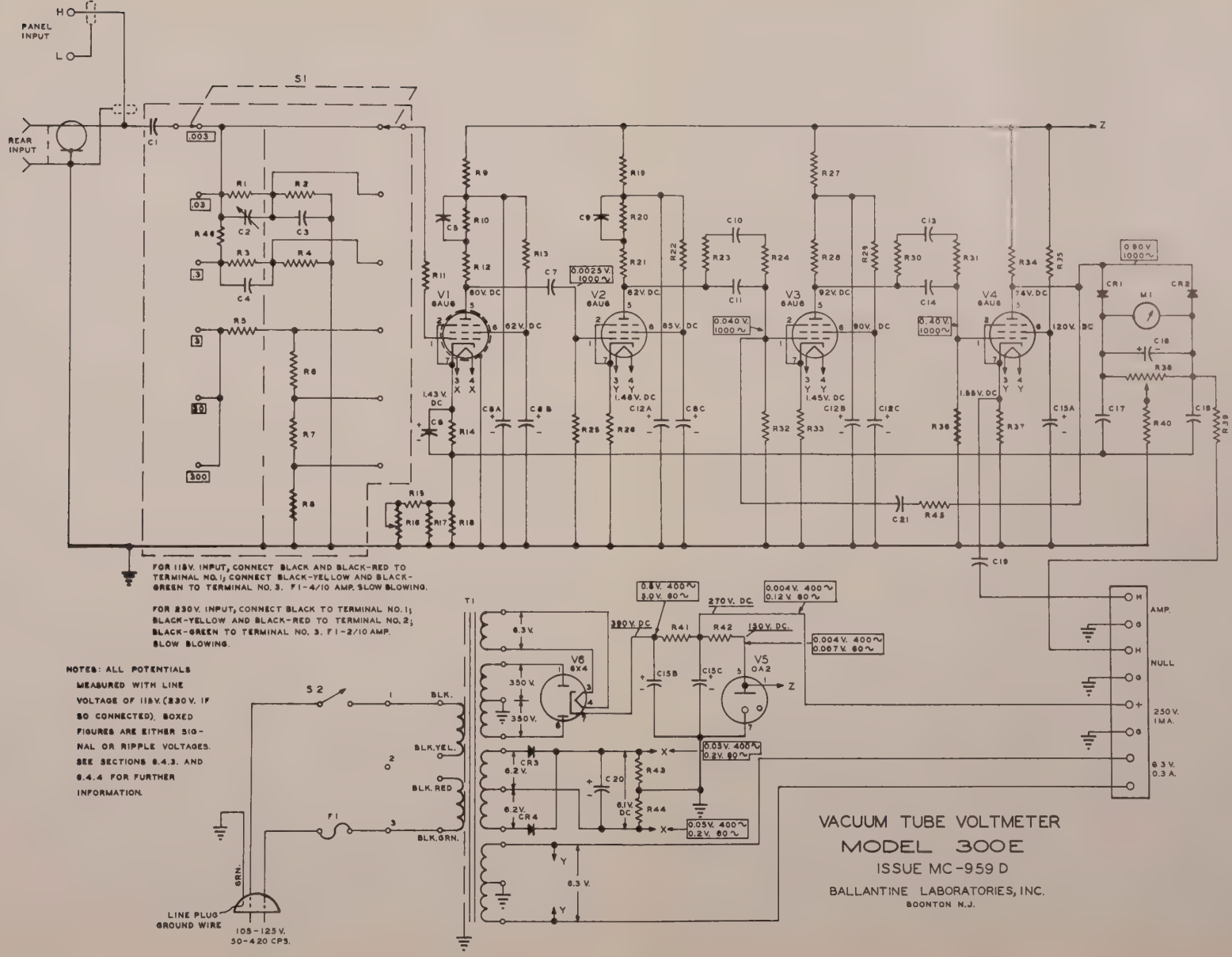
8. SHIPPING INSTRUCTIONS

If it should become necessary to return the voltmeter to Ballantine Laboratories, Inc. for examination or servicing, it should be very carefully packed with at least 4 inches of cushioning material placed around all sides of the instrument to prevent damage during shipment. Ship via Railway Express and send under separate cover a full description of the trouble or defect. Do not ship via Parcel Post.



BLOCK DIAGRAM

MODEL 300 E, F ELECTRONIC VOLTMETER



VACUUM TUBE VOLTMETER
MODEL 300E

ISSUE MC-959 D

BALLANTINE LABORATORIES, INC.
BOONTON N.J.

REPLACEMENT PARTS LIST

REFER TO MODEL 300E SCHEMATIC DIAGRAM, ISSUE MC-959D

B. L. Part #	Circuit Symbol	CAPACITORS	Manufacturer
2363	C1	0.1 uf, Type 355F104J, 5%, 600 V	Gudeman
2437	C2	0.7-9 uuf, Type VC1G	JFD
2235	C3	33 uuf, Type CM15-E, 5%, 500 V	Arco
	C4	Value determined in Calibration	
2228	C5	50 uuf, Type CM15-E, 5%, 500 V	Arco
2036	C6	500 uf, Type FP, 25 V	Magnavox
2364	C7	0.033 uf, Type 355C333J, 5%, 200 V	Gudeman
2042	C8A	50 uf, Type FP, 150 V	Magnavox
2042	C8B	50 uf, Type FP, 150 V	Magnavox
2042	C8C	50 uf, Type FP, 150 V	Magnavox
2240	C9	20 uuf, Type CM15-C, 5%, 500 V	Arco
2362	C10	0.22 uf, Type 355C224J, 5%, 200 V	Gudeman
2365	C11	0.01 uf, Type 355C103J, 5%, 200 V	Gudeman
2042	C12A	50 uf, Type FP, 150 V	Magnavox
2042	C12B	50 uf, Type FP, 150 V	Magnavox
2042	C12C	50 uf, Type FP, 150 V	Magnavox
2362	C13	0.22 uf, Type 355C224J, 5%, 200 V	Gudeman
2366	C14	0.0022 uf, Type 355C222J, 5%, 200 V	Gudeman
2043	C15A	10 uf, Type FP, 500 V	Magnavox
2043	C15B	10 uf, Type FP, 500 V	Magnavox
2043	C15C	10 uf, Type FP, 500 V	Magnavox
2055	C16	25 uf, Type DPE-14395, 25 V	Sprague
2368	C17	1 uf, Type 355C105J, 5%, 200 V	Gudeman
2368	C18	1 uf, Type 355C105J, 5%, 200 V	Gudeman
2367	C19	0.1 uf, Type 355C104K, 10%, 200 V	Gudeman
2019	C20	1000 uf, Type FP, 15 V	Magnavox
	C21	Value determined in Calibration	

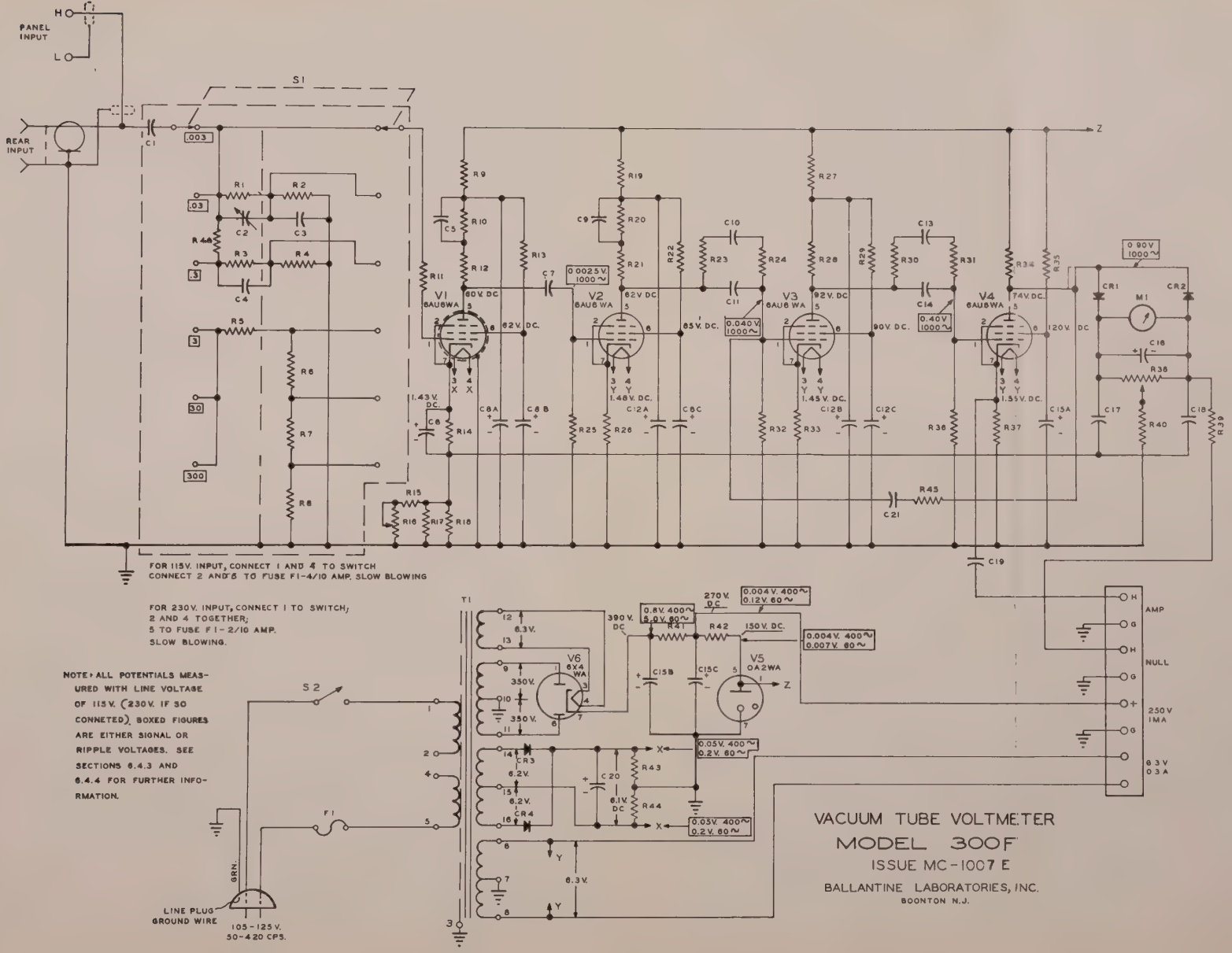
OTHER COMPONENTS

3047	T1	Power Transformer	Ballantine
3410	F1	Fuse, 0.4 amp, Slo-Blow	Bussman
3180	M1	Indicating Meter, Special	Ballantine
3258	S1	Range Selector Switch	Ballantine
3234	S2	Switch, ON-OFF	Arrow, Hart, Hegeman
3109	V1,2,3,4	Type 6AU6 Tube	R.C.A.
3106	V5	Type OA2 Tube	R.C.A.
3105	V6	Type 6X4 Tube	R.C.A.
5558	CR1,2	Diodes, Type S8G, Special	Transitron
5559	CR3,4	Diodes, Type TM1, Special	Transitron

REPLACEMENT PARTS LIST

REFER TO MODEL 300E SCHEMATIC DIAGRAM, ISSUE MC-959D

B. L. Part #	Circuit Symbol	RESISTORS	Manufacturer
1476	R1	1,800,000 ohms, Type PT-1000	Ballantine
1441	R2	200,000 ohms, Type PT-500	Ballantine
1477	R3	2,000,000 ohms, Type PT-1000	Ballantine
1442	R4	20,200 ohms, Type PT-500	Ballantine
1477	R5	2,000,000 ohms, Type PT-1000	Ballantine
1443	R6	1,800 ohms, Type PT-500	Ballantine
1444	R7	180 ohms, Type PT-500	Ballantine
1445	R8	20 ohms, Type PT-500	Ballantine
1081	R9	27,000 ohms, Type EB, 5%	Allen-Bradley
1660	R10	47,000 ohms, Type N20, 1%	Corning Glass
1097	R11	47 ohms, Type EB, 5%	Allen-Bradley
1047	R12	5,100 ohms, Type EB, 5%	Allen-Bradley
1085	R13	120,000 ohms, Type EB, 5%	Allen-Bradley
1057	R14	1,000 ohms, Type EB, 5%	Allen-Bradley
1357	R15	68 ohms, Type CP-1/2, 1%	Wilkor
1921	R16	10,000 ohms, Type J Pot, 20%	Allen-Bradley
	R17	Value determined in calibration	
	R18	2.24 ohms, Special	Ballantine
1042	R19	15,000 ohms, Type EB, 5%	Allen-Bradley
1043	R20	12,000 ohms, Type EB, 5%	Allen-Bradley
1046	R21	7,500 ohms, Type EB, 5%	Allen-Bradley
1039	R22	22,000 ohms, Type EB, 5%	Allen-Bradley
1010	R23	1,000,000 ohms, Type EB, 5%	Allen-Bradley
1010	R24	1,000,000 ohms, Type EB, 5%	Allen-Bradley
1012	R25	750,000 ohms, Type EB, 5%	Allen-Bradley
1061	R26	510 ohms, Type EB, 5%	Allen-Bradley
1046	R27	7,500 ohms, Type EB, 5%	Allen-Bradley
1044	R28	10,000 ohms, Type EB, 5%	Allen-Bradley
1081	R29	27,000 ohms, Type EB, 5%	Allen-Bradley
1010	R30	1,000,000 ohms, Type EB, 5%	Allen-Bradley
1010	R31	1,000,000 ohms, Type EB, 5%	Allen-Bradley
1014	R32	510,000 ohms, Type EB, 5%	Allen-Bradley
1062	R33	390 ohms, Type EB, 5%	Allen-Bradley
1041	R34	18,000 ohms, Type EB, 5%	Allen-Bradley
1042	R35	15,000 ohms, Type EB, 5%	Allen-Bradley
1014	R36	510,000 ohms, Type EB, 5%	Allen-Bradley
1063	R37	300 ohms, Type EB, 5%	Allen-Bradley
1920	R38	500,000 ohms, Type J Pot, 20%	Allen-Bradley
1010	R39	1,000,000 ohms, Type EB, 5%	Allen-Bradley
1463	R40	10,000,000 ohms, Type CP-1, 1%	Wilkor
1719	R41	4,000 ohms, Type 27E, 5%	Sprague
1719	R42	4,000 ohms, Type 27E, 5%	Sprague
1063	R43	300 ohms, Type EB, 5%	Allen-Bradley
1063	R44	300 ohms, Type EB, 5%	Allen-Bradley
1005	R45	3,000,000 ohms, Type EB, 5%	Allen-Bradley
1005	R46	3,000,000 ohms, Type EB, 5%	Allen-Bradley



VACUUM TUBE VOLTMETER
MODEL 300F

ISSUE MC-1007 E

BALLANTINE LABORATORIES, INC.
BOONTON N.J.

REPLACEMENT PARTS LIST

REFER TO MODEL 300F SCHEMATIC DIAGRAM, ISSUE MC-1007E

B. L. Part #	Circuit Symbol	RESISTORS	Manufacturer
1476	R1	1,800,000 ohms, Type PT-1000	Ballantine
1441	R2	200,000 ohms, Type PT-500	Ballantine
1477	R3	2,000,000 ohms, Type PT-1000	Ballantine
1442	R4	20,200 ohms, Type PT-500	Ballantine
1477	R5	2,000,000 ohms, Type PT-1000	Ballantine
1443	R6	1,800 ohms, Type PT-500	Ballantine
1444	R7	180 ohms, Type PT-500	Ballantine
1445	R8	20 ohms, Type PT-500	Ballantine
1081	R9	27,000 ohms, Type EB, 5%	Allen-Bradley
1660	R10	47,000 ohms, Type N20, 1%	Corning Glass
1097	R11	47 ohms, Type EB, 5%	Allen-Bradley
1047	R12	5,100 ohms, Type EB, 5%	Allen-Bradley
1085	R13	120,000 ohms, Type EB, 5%	Allen-Bradley
1057	R14	1,000 ohms, Type EB, 5%	Allen-Bradley
2663	R15	71.5 ohms, Type CP-1/2, 1%	Wilkor
1923	R16	1,000 ohms, Type J pot, 20%	Allen-Bradley
	R17	Value determined in Calibration	
	R18	2.24 ohms, Special	Ballantine
1042	R19	15,000 ohms, Type EB, 5%	Allen-Bradley
1043	R20	12,000 ohms, Type EB, 5%	Allen-Bradley
1046	R21	7,500 ohms, Type EB, 5%	Allen-Bradley
1039	R22	22,000 ohms, Type EB, 5%	Allen-Bradley
1010	R23	1,000,000 ohms, Type EB, 5%	Allen-Bradley
1010	R24	1,000,000 ohms, Type EB, 5%	Allen-Bradley
1012	R25	750,000 ohms, Type EB, 5%	Allen-Bradley
1061	R26	510 ohms, Type EB, 5%	Allen-Bradley
1046	R27	7,500 ohms, Type EB, 5%	Allen-Bradley
1044	R28	10,000 ohms, Type EB, 5%	Allen-Bradley
1081	R29	27,000 ohms, Type EB, 5%	Allen-Bradley
1010	R30	1,000,000 ohms, Type EB, 5%	Allen-Bradley
1010	R31	1,000,000 ohms, Type EB, 5%	Allen-Bradley
1014	R32	510,000 ohms, Type EB, 5%	Allen-Bradley
1062	R33	390 ohms, Type EB, 5%	Allen-Bradley
1041	R34	18,000 ohms, Type EB, 5%	Allen-Bradley
1042	R35	15,000 ohms, Type EB, 5%	Allen-Bradley
1014	R36	510,000 ohms, Type EB, 5%	Allen-Bradley
1063	R37	300 ohms, Type EB, 5%	Allen-Bradley
1922	R38	500,000 ohms, Type J Pot, 20%	Allen-Bradley
1010	R39	1,000,000 ohms, Type EB, 5%	Allen-Bradley
1475	R40	10,000,000 ohms, Type C-177AN, 1%	Mepco
1730	R41	4,000 ohms, Type SP-RW55G402, 5%	Sprague
1730	R42	4,000 ohms, Type SP-RW55G402, 5%	Sprague
1063	R43	300 ohms, Type EB, 5%	Allen-Bradley
1063	R44	300 ohms, Type EB, 5%	Allen-Bradley
1005	R45	3,000,000 ohms, Type EB, 5%	Allen-Bradley
1005	R46	3,000,000 ohms, Type EB, 5%	Allen-Bradley

REPLACEMENT PARTS LIST

REFER TO MODEL 300F SCHEMATIC DIAGRAM, ISSUE MC-1007E

B. L. Part #	Circuit Symbol	CAPACITORS	Manufacturer
2176	C1	0.1 uf, Type 91P10456S4, 5%, 600 V	Sprague
2437	C2	0.7-9 uuf, Type VC1G	JFD
2235	C3	33 uuf, Type CM15-E, 5%, 500 V	Arco
	C4	Value determined in Calibration	
2228	C5	50 uuf, Type CM15-E, 5%, 500 V	Arco
2048	C6	500 uf, Type SP-CE516501E, 15 V	Sprague
2177	C7	0.033 uf, Type SP-CE51C501E, 15 V	Sprague
2046	C8A	60 uf, Type 91P33352S4, 5%, 200 V	Sprague
2046	C8B	60 uf, Type SP-CE53C600J, 150 V	Sprague
2046	C8C	60 uf, Type SP-CE53C600J, 150 V	Sprague
2240	C9	20 uuf, Type CM15-C, 5%, 500 V	Arco
2175	C10	0.22 uf, Type 91P22452S4, 5%, 200 V	Sprague
2178	C11	0.01 uf, Type 91P10352S4, 5%, 200 V	Sprague
2046	C12A	60 uf, Type SP-CE53C600J, 150 V	Sprague
2046	C12B	60 uf, Type SP-CE53C600J, 150 V	Sprague
2046	C12C	60 uf, Type SP-CE53C600J, 150 V	Sprague
2175	C13	0.22 uf, Type 91P22452S4, 5%, 200 V	Sprague
2179	C14	0.0022 uf, Type 91P22252S4, 5%, 200 V	Sprague
2047	C15A	10 uf, Type SP-CE53F100R, 450 V	Sprague
2047	C15B	10 uf, Type SP-CE53F100R, 450 V	Sprague
2047	C15C	10 uf, Type SP-CE53F100R, 450 V	Sprague
2578	C16	35 uf, Type Tantalum, 6 V	Fansteel
2174	C17	1 uf, Type 91P10552S13, 5%, 200 V	Sprague
2174	C18	1 uf, Type 91P10552S13, 5%, 200 V	Sprague
2180	C19	0.1 uf, Type 91P10402S4, 10%, 200 V	Sprague
2045	C20	1200 uf, Type SP-CE51C122E, 15 V	Sprague
2200	C21	1 uuf, Type CM-15-C, 5%, 500 V	Arco

OTHER COMPONENTS

3049	T1	Power Transformer, Special	Ballantine
3410	F1	Fuse, 0.4 amp, Slo-Blow	Bussman
3180	M1	Indicating Meter, Special	Ballantine
3259	S1	Range Selector Switch	Ballantine
3260	S2	Switch, ON-OFF	Arrow, Hart, Hegeman
5564	V1,2,3,4	Type 6AU6WA Tube	R.C.A.
5565	V5	Type OA2WA Tube	R.C.A.
5566	V6	Type 6X4WA Tube	R.C.A.
5567	CR1,2	Diodes, Type IN251	Transitron
5568	CR3,4	Diodes, Type IN253	Transitron

BALLANTINE LABORATORIES - BOONTON - N. J.

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